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nImportant Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

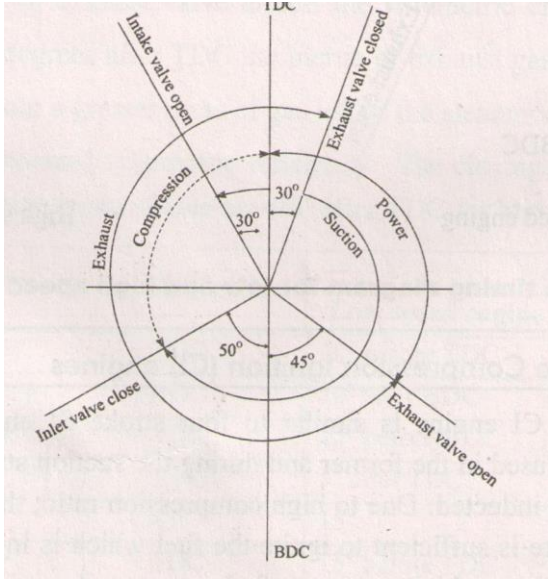| Q. No.	Sub Q. No.	Answer	Marking Scheme
1.A		**Attempt any THREE**	
	a)	Diesel Cycle on P-V and T-S diagram : Processes : 1-2 : Isentropic compression 2-3 : Heat addition at constant pressure 3-3 Isentropic expansion 4-1 Heat rejection at constant volume	**Fig. 3 Marks 1 for processes**

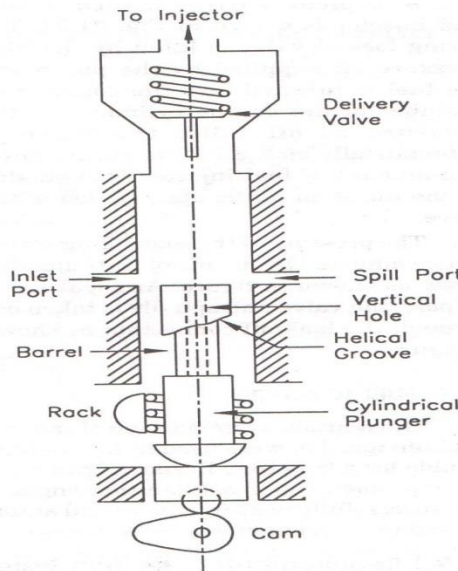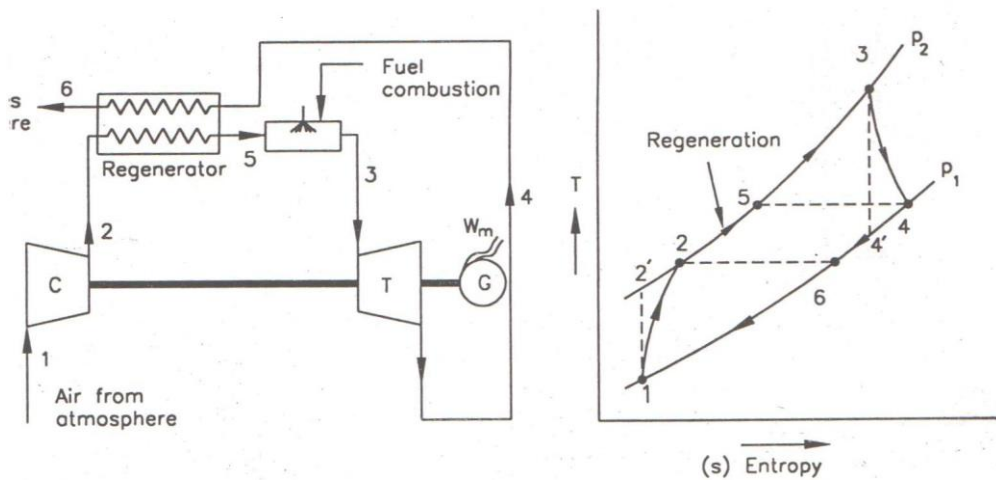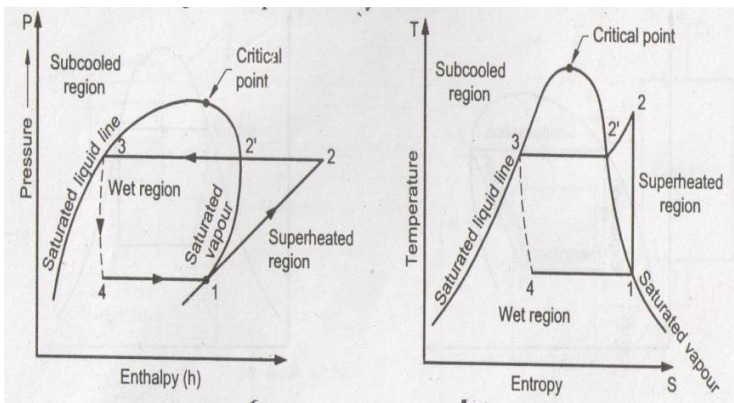|			
b)		**Valve timing diagram of four stroke diesel engine** 	

	c)	**Classification of Air compressors**:
		
		1. According to principle:
		
		   a) Reciprocating air compressors
		
		   b) Rotary air compressors
		
		2. According to the capacity
		
		   a. Low capacity air compressors
		
		   b. Medium capacity air compressors
		
		   c. High capacity air compressors
		
		3. According to pressure limits
		
		   a. Low pressure air compressors
		
		   b. Medium pressure air compressors
		
		   c. High pressure air compressors
		
		4. According to method of connection
		
		   a. Direct drive air compressors
		
		   b. Belt drive air compressors
		
		   c. Chain drive air compressors
			1 mark each

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Classification of gas turbine on the basis of

a. Cycle of operation

1. Open cycle

2. Closed cycle

b. Thermodynamic cycle

1. Brayton or Joules cycle

2. Atkinson cycle

3. Erricsson cycle

c. Application

1. For supercharging of IC engine

2. For locomotive propulsion

3. For ship propulsion

4. Industrial application

5. Air craft engines

6. Electric power generation

d. Combustion process

1. Continuous combustion

2. Explosion combustion

1.B		**Attempt any ONE**	
	a)	**Fuel injection pump** : Fuel injection pump is used widely for the supply of fuel under high pressure in diesel engines. 	
	b)	**Regenerative method to improve thermal efficiency in gas turbines** : The exhaust gases a lot of heat as their temperature is far above the ambient temperature . The heat of exhaust gases can be used to heat the air coming from the compressor thus reducing the mass of the fuel supplied in the combustion chamber as shown in the figure. This method is called regenerative method. 	

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2		**Attempt any TWO**	
	a)	$$Q2 \,(a)\quad I.P. = \frac{n}{n-1} mRT_1 \left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right]$$ $$= \frac{n}{n-1} mRT_1 \left[\frac{T_2}{T_1} - 1\right] \quad \text{—2 marks}$$ $$= \frac{1.3}{1.3-1} \times 6 \times 0.287 \times 298 \left[\frac{378}{298} - 1\right]$$ $$= 9.9\,kw \quad - 3\ marks$$ $$\eta_{mech.} = \frac{I.P.}{Shaft\ Power} = \frac{9.9}{14} = 70.71\% \quad - 3\ marks$$	**8 marks**
	b)	**Vapour Compression Refrigeration Cycle** The P-H and T-S diagram for the simple vapor compression refrigeration cycle is shown in the figure for vapour entering the compressor is in dry saturation condition The dry and saturated vapour entering the compressor at point 1 that vapour compresses isentropic ally from point 1 to 2 which increases the pressure from evaporator pressure to condenser pressure	**Fig. 4 marks explanation 4 marks**

At point 2 the saturated vapour enters the condenser where heat is rejected at constant pressure, due to rejection of heat decreases the temperature and change of phase takes place i.e. latent heat is removed and reaches to liquid saturation temperature at point 3 then this liquid refrigerant passed through expansion valve where liquid refrigerant is throttle keeping the enthalpy constant and reducing the pressure.

c)

$Q2$ (6)

B.P. developed when all cylinders $= 16.2$ kw working

I.P. of first cylinder I.P$_1$ $= 16.2 - 11.5 = 4.7$ kw

—"— second —"— I.P$_2$ $= 16.2 - 11.6 = 4.6$ kw

—"— third —"— I.P$_3$ $= 16.2 - 11.68 = 4.52$ kw

—"— fourth —"— I.P$_4$ $= 16.2 - 11.57 = 4.63$ kw
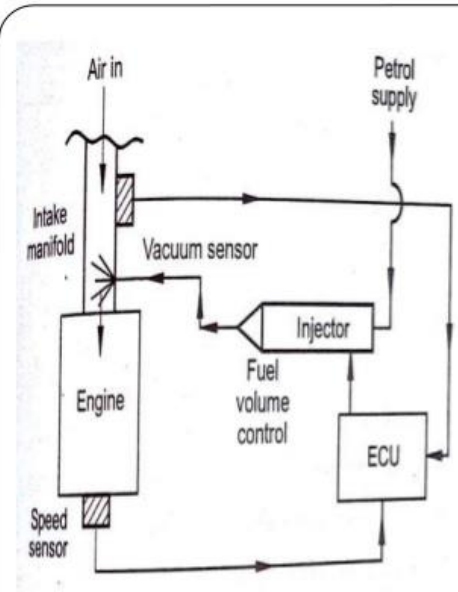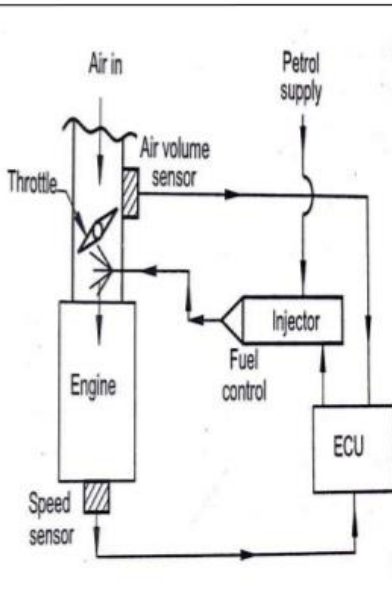
(1 mark each)

Total I.P. $=$ I.P$_1$ + I.P$_2$ + I.P$_3$ + I.P$_4$

$= 4.7 + 4.6 + 4.52 + 4.63$

$= 18.45$ kw   (2 marks)

$\eta_{mechanical} = \dfrac{B.P.}{I.P.}$

$= \dfrac{16.2}{18.45}$

$= 87.8\%$ (2 marks)

FP = IP – BP= 18.45-16.2 = 2.25 KW.

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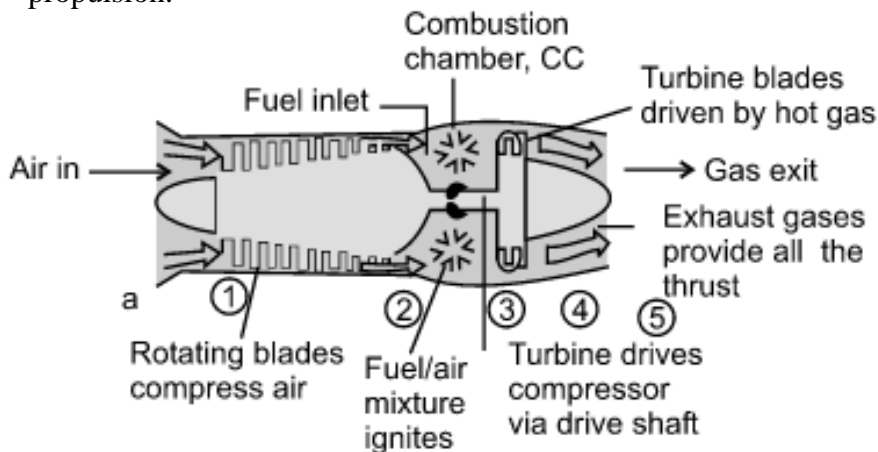| 3	a)	**Attempt any FOUR MPFI :** MPFI means Multipoint Injection System in which each cylinder has number of injector to supply / spray the fuel in cylinders.	
	a)	• The MPFI electronic system is also classified as 1) D-MPFI system: The main input signal are the <u>intake manifold pressure, Engine speed and flow volume of air</u> which are sent to ECU to control the A/F ratio. 2) L-MPFI system: The main input signal are <u>air flow rate and engine speed</u> to regulate fuel quantity injected. • The both system mentioned above, sends the information of respective sensors to ECU and then ECU processes the information and sends commend to fuel injector to regulate fuel injected. Then the mixture formed enters into the engine. MPFI result in 1. Superior fuel consumption, 2. Better fuel management, 3. Better engine performance, 4. Reduce pollution. D-MPFI SYSTEM L-MPFI SYSTEM	**02 MARKS SKETCH & 02 MARKS FOR EXPLAIN**

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	b)	**Difference between Turbocharger and Supercharger**		ANY FOUR DIFF.01 MARK EACH

S.no	Turbocharging	Supercharging
1.	Turbocharger is a forced induction system that compresses the atmospheric gases and sends it to the engine cylinder.	Super charger is also a forced induction system. It compresses the atmospheric air and sends it to the engine cylinder.
2.	It uses exhaust gases for its energy.	It is connected to the crankshaft of the engine for its energy.
3.	It is not directly connected to the engine.	It is directly connected to the engine through belt.
4.	It has smog altering equipment which helps in lowering the carbon emission.	It doesn't have waste gate, so the smog emits from the supercharger.
5.	It spins with a speed up to 150000 rpm.	It spins with a speed upto 50000 rpm.
6.	It is much quieter than supercharger.	It is not so quieter.
7.	It is less reliable.	It is more reliable.
8.	Maintenance is not easy.	Maintenance is easy.
9.	Turbocharger delivers their boost better at high rpm.	Supercharger can deliver their boost at lower rpm.
10.	It is more efficient.	It is less efficient.
11.	The compressed air in turbocharger has high temperature.	The compressed air in supercharger has less temperature.
12.	It requires intercooler for the compressed air to lower its temperature.	It may or may not require intercooler. But in some types, it requires intercooler.
13.	It is more complex.	It is less complex.
14.	It has lag problem due to discontinuous supply of energy.	It has negligible lag problem because of continuous supply of energy by crankshaft.
15.	The compressor is rotated by the turbine.	The compressor is rotated by the engine crankshaft through a belt.

	c)	**Additives** **(any four – 4 marks)**	

(1) Detergents – To keep engine parts, such as piston and piston rings, clean & free from deposits.

(2) Dispersants – To suspend & disperse material that could form varnishes, sludge etc that clog the engine.

(3) Anti – wear – To give added strength & prevent wear of heavily loaded surfaces such

as crank shaft rods & main bearings.

(4) Corrosion inhibitors – To fight the rust wear caused by acids moisture. Protect vital steel & iron parts from rust & corrosion.

(5) Foam inhibitors – control bubble growth, break them up quickly to prevent frothing & allow the oil pump to circulate oil evenly.

(6) Viscosity index improver – added to adjust the viscosity of oil.

(7) Pour point depressant - improves an oil ability to flow at very low temperature.

d)	**Working principle of Turbojet**: shows the schematic of turbojet engine. It has a diffuser section at inlet for realizing some compression of air passing through this section. Due to this air reaching compressor section has pressure more than ambient pressure. This action of partly compressing air by passing it through diffuser section is called "ramming action" or "ram effect". Subsequently compressor section compresses air which is fed to combustion chamber and fuel is added to it for causing combustion. Combustion products available at high pressure and temperature are then passed through turbine and expanded there. Thus, turbine yields positive work which is used for driving compressor. Expanding gases leaving turbine are passed through exit nozzle where it is further expanded and results in high velocity jet at exit. This high velocity jet leaving nozzle is responsible for getting desired thrust for propulsion. 	**Working – 2 marks** **Fig.- 2 marks**
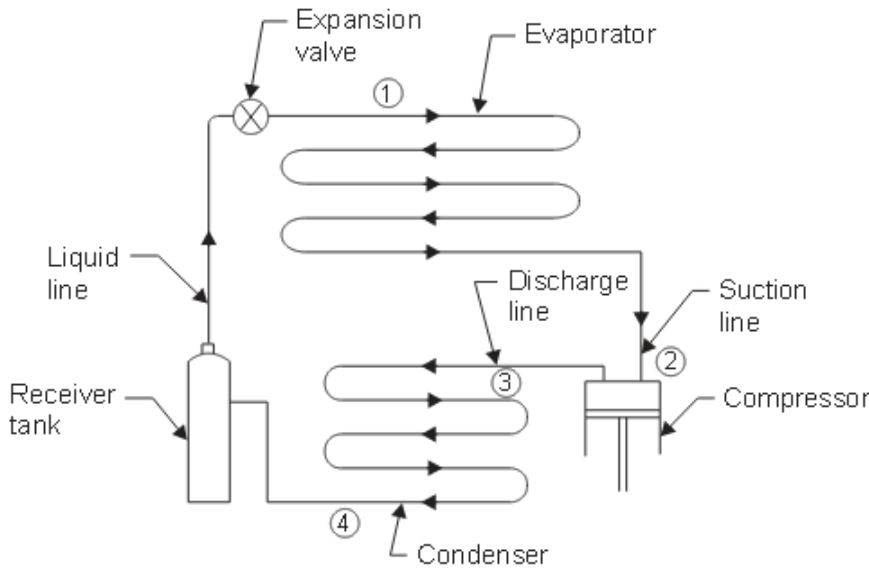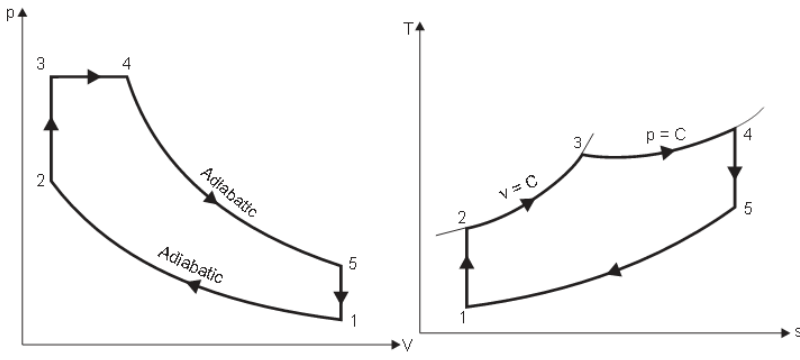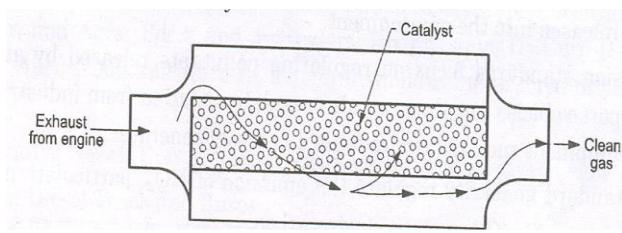
	e)	**Advantages of closed cycle gas turbine over open cycle gas turbine:** **(i)** It has higher thermal efficiency for the same minimum and maximum temperature limits and for the same pressure ratio. (ii) Since the heating is external, any kind of fuel even solid fuel having low calorific value may be used. (iii) There is no corrosion due to circulation of combustion product. (iv) As the system is a closed one there is no loss of the working fluid. (v) The size of the turbine will be smaller compared to an open cycle gas turbine of the same output. (vi) The regulation is more simple. (vii) The heat transmission coefficient in the exchanger is better due to the increase in suction pressure. (viii) Loss due to fluid friction is less due to higher Reynolds number.	**Any four 1 mark each**
4	**A**	**Attempt any THREE**	
	a)	(i) **Indicated Power:** The total power developed by combustion of fuel in the combustion chamber is called indicated power. (ii) **Brake Power**: The power developed by an engine at the output shaft is called brake power. (iii) **Volumetric efficiency**: It is defined as the ratio of the actual volume of the charge admitted into the cylinder to the swept volume of the piston is known as volumetric efficiency. **(iv) Brake specific fuel consumption**: It is the mass of fuel consumed per kw developed per hour, and is a criterion of economical	
	b)	(i) **Swept Volume (V_S) w.r.t I.C.Engine**: The volume swept through by the piston in moving between top dead centre and bottom dead centre is called swept volume or piston displacement. It is denoted by V_S. It is equal to the area of the piston multiplied by its stroke length. Therefore, Swept Volume = $\pi/4 \times D^2 \times L$ Where D = bore of the cylinder in m, and L = stroke length in m. (ii) **Swept Volume (V_S) w.r.t. Reciprocating air compressor**: It is the actual volume of air taken in during suction stroke. It is expressed in m^3. Swept volume when expressed in m^3/min, it is known as piston displacement.	**2 marks each**

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	c)	**Block diagram of Vapour Compression cycle** 	
	d)	**Duel cycle:** (i) Cut off ratio w.r.t. Duel Cycle: $\rho = V_4/V_3$ (ii) Pressure ratio w.r.t. Duel Cycle: $\alpha = P_3/P_2$	
4	**B**	**Attempt any ONE**	
	a)	**Catalytic converter:** Catalytic converter is a device which converts harmful pollutants to	Fig. 2 Marks explanation 4 Marks

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harmless gases. Catalytic converter is used in exhaust emission in control system to convert CO, NO_x, HC and other harmful gases to harmless gases.

A Catalytic converter consists of a cylindrical unit of small size like a small silencer and is installed into the exhaust system of a vehicle. It is placed between the exhaust manifold and the silencer.

Inside the cylindrical tube i.e. converter there is a honey comb structure of a 'ceramic or metal' which is coated with 'alumina base' material and there after a second coating of precious metals 'platinum, palladium or rhodium' or combination of the same. This second coating serves as a catalyst. A catalyst is a substance which causes a chemical reaction intro the gases. When the exhaust gases pass over the converter substance, the toxic gases as CO, HC & NO_x are converted into harmless gases as CO_2, H_2 & N_2.

	Superimposed P-V Diagram of Otto, Diesel & Duel Cycle:	**CYCLE 03 marks & Comparison 03 Marks**

Superimposed P-V Diagram of Otto, Diesel & Duel Cycle:

A comparison of the cycles (Otto, Diesel and Dual) on the p-v and T-s diagrams for the same compression ratio and heat supplied is shown in the Fig.

Since all the cycles reject their heat at the same specific volume, process line from state 4 to 1, the quantity of heat rejected from each cycle is represented by the appropriate area under the line 4 to 1 on the T-s diagram. As is evident from the cycle which has the least heat rejected will have the highest efficiency. Thus, Otto cycle is the most efficient and Diesel cycle is the least efficient of the three cycles.

b)

Comparison of efficiency at various compression ratios.

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(a)   (b)

Otto = 1, 2, 3″, 4″
Diesel = 1, 2, 3, 4
Dual = 1′, 2′, 3′, 4′

5		**Attempt any TWO**	
	a)	**Following are the methods to improve efficiency of air compressor**	**4 Marks**

1.   Cooling cylinder by spraying water during compression stroke.

2.   Circulation of water surrounding to cylinder by providing jackets

3.   Installing inter cooler between two cylinders

4.   Providing greater fins on cylinder

5.   By selecting suitable material for cylinder

6.   By providing suitable choice of cylinder proportions i.e. short stroke and
     large bore in construction with sleeve valve

Two stage reciprocating air compressor :

Two stage reciprocating compressor

Fig. 2 Marks

Explanation 2 Marks

Multistage   compression   refers   to   the   compression   process completed in more than one stage i.e. a part of compression occurs in one cylinder (L.P. cylinder) and subsequently compressed air is sent to subsequent cylinders (H.P. cylinder) for further compression.

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		Figure shows the schematic of two stage compressor with intercooler between stages. The total work requirement for running this shall be algebraic summation of work required for low pressure (LP) and high pressure (HP) stages. The size of HP cylinder is smaller than LP cylinder as HP cylinder handles high pressure air having smaller specific volume. Intake temp of air at LP =intake temp of air at HP for perfect intercooling.	
	b)	**Applications of Reciprocating Compressor (Any Four, each for 1 mark)** 1. In spray painting shop. 2. In workshop for cleaning machines. 3. For operation of pneumatic tool like rock drill, vibrator etc. 4. In automobile service station to clean vehicle. 5. To drive air motors in coal mines. 6. Food and beverage industry **Applications of Centrifugal Compressor (Any Four, each for 1 mark)** 1. In gas turbines and auxiliary power units. 2. In automotive engine and diesel engine turbochargers and superchargers. 3. In pipeline compressors of natural gas to move the gas from the production site to the consumer. 4. In oil refineries, natural gas processing, petrochemical and chemical plants. 5. Air-conditioning and refrigeration and HVAC: Centrifugal compressors quite often supply the compression in water chillers cycles. 6. In air separation plants to manufacture purified end product gases. 7. In oil field re-injection of high pressure natural gas to improve oil recovery.	
	c)	The major air pollutants emitted by petrol & diesel engines are CO_2, CO, HC, NO_x, SO_2, smoke & lead vapour. **Effect of CO**: • Carbon monoxide combines with hemoglobin forming carboy	**Any four pollutants & Its effect**

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		hemoglobin ,which reduces oxygen carrying capacity of blood.		**2 marks each**

- This leads to laziness, exhaustion of body & headache.

- Prolong exposure can even leads to death.

- It also affects cardiovascular system, thereby causing heart problem

Effect of CO_2: Causes respiratory disorder & suffocation.

Effect of NO_x:

It causes respiration irritation, headache, bronchitis, pulmonary emphysema, impairment of lungs, and loss of appetite & corrosion of teeth to human body.

Effect of HC:

- It has effect like reduced visibility, eye irritation, peculiar odour & damage to vegetation & acceleration the cracking of rubber products.

- It induce cancer, affect DNA & cell growth are know a carcinogens.

Effect of SO_2: It is toxic & corrosive gas, human respiratory track of animals, plants & crops.

6		**Attempt any FOUR**	
	a)	**i) Daltons Law of partial pressure** – It states that the total pressure of mixture of gases is equal to the sum of the partial pressures exerted by each gas when it occupies the mixture volume at the temperature of mixture.	**2 Marks each**

Consider mixture of gas having constituents as gas a. gas b, gas c

Then, Total pressure $P_t = P_a + P_b + P_c$

ii) Relative humidity:- It is defined as the ratio of partial pressure of water vapour in a given volume of mixture to the partial pressure of water vapour when same volume of mixture is saturated at the same temperature.

$$\therefore \phi = \frac{\dfrac{P_V}{P_V \, sat}}{} \times 100$$

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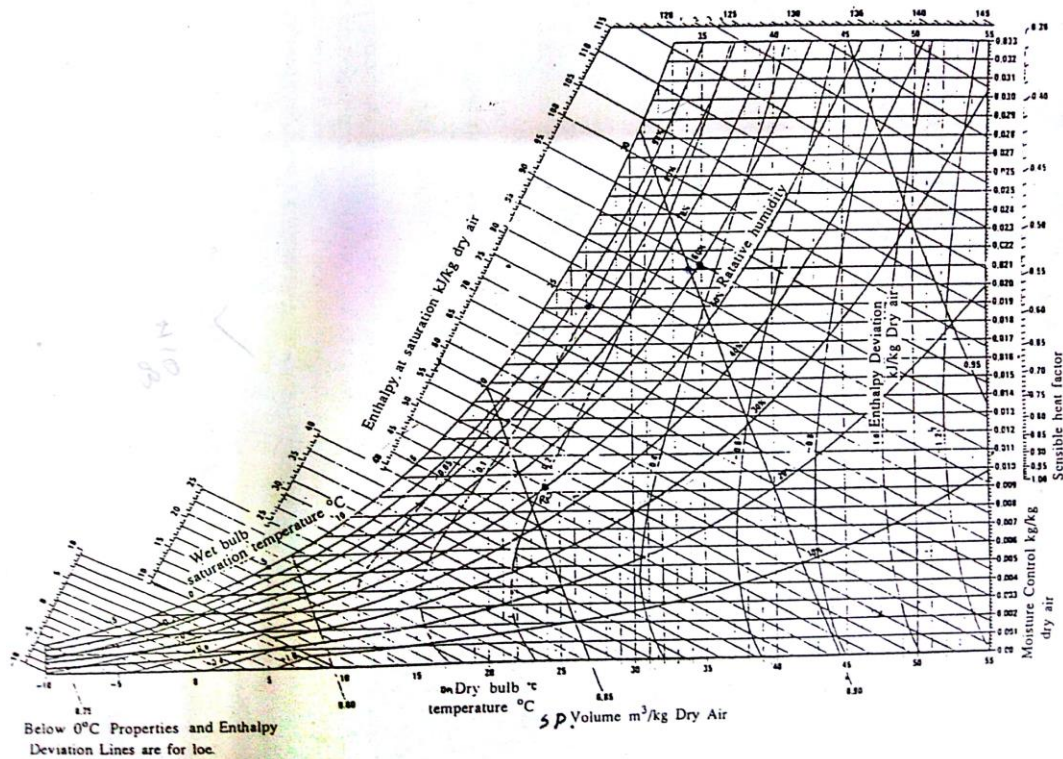
	b)		**1 Mark each**
	c)	**Sketch of window air conditioner**	

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	d)	**Following are the applications of compressed air (Any Eight) 1/2 mark each** 1) To drive air motors in coal mines. 2) To inject fuel in air injection diesel engines. 3) To operate pneumatic drills, hammers, hoists, sand blasters. 4) For cleaning purposes. 5) To cool large buildings. 6) In the processing of food and farm maintenance. 7) For spray painting in paint industry. 8) In automobile & railway braking systems. 9) To operate air tools like air guns. 10) To hold & index cutting tools on machines like milling.	
	e)	Following are the applications of gas turbine 1. It is used for electric power generation. 2. It is used for locomotive propulsion. 3. It is used for ship propulsion. 4. Gas turbine is used in aircrafts. 5. It is used for supercharging for heavy duty Diesel engines. 6. Used in turbo jet and turbo-propeller engine. 7. It is used for various industrial purpose such as in steel industry, oil and other chemical industry.	**Any 4 App. 1 mark each**